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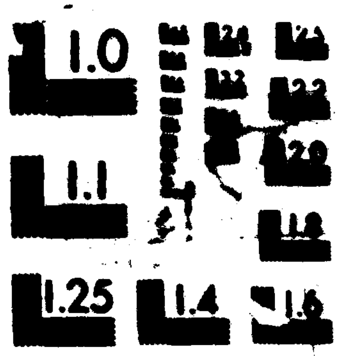

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HUMAN RESOURCES

INTEGRATED MAINTENANCE INFORMATION SYSTEM: TRAINING TECHNOLOGY SCENARIOS

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Craig M. Brandt
Johnnie H. Jernigan
Ronald J. Dierker

Systems Exploration, Incorporated
5200 Springfield Pike, Suite 312
Dayton, Ohio 45431

LOGISTICS AND HUMAN FACTORS DIVISION
Wright-Patterson Air Force Base, Ohio 45433-6503

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BROOKS AIR FORCE BASE, TEXAS 78235-5601

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Contract Monitor

BERTRAM W. CREAM, Technical Director
Logistics and Human Factors Division

DONALD C. TETMEYER, Colonel, USAF
Chief, Logistics and Human Factors Division

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The Air Force's proposed Integrated Maintenance Information System (IMIS) will make it possible for maintenance personnel to access several automated maintenance information systems by using a portable computer system and a common protocol. The information systems to be integrated by the IMIS include the Automated Technical Order System (ATOS), the Core Automated Maintenance System (CAMS), supply systems, and computer-based training systems. Work is currently being accomplished in several areas to provide the basis for defining requirements for the IMIS. In the present investigation, potential training applications for the IMIS were examined. An analysis was made of base-level training requirements, and scenarios were developed to demonstrate how IMIS could be used to provide the required training.

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Craig M. Brandt
Johnnie M. Jernigan
Ronald J. Dierker

Systems Exploration, Incorporated
5200 Springfield Pike, Suite 312
Dayton, Ohio 45431

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LOGISTICS AND HUMAN FACTORS DIVISION
Wright-Patterson Air Force Base, Ohio 45433-6503

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SUMMARY

The Air Force Human Resources Laboratory (AFHRL) is developing an Integrated Maintenance Information System (IMIS). IMIS will demonstrate the capability to access and integrate information from multiple sources and present the information to technicians through a rugged, hand-held computer. Results of the program will form the basis of requirement specifications for such a system.

AFHRL is performing preliminary research in many areas key to the success of the IMIS concept. These areas include digital authoring and presentation of maintenance instructions, integrated diagnostics aiding, human-computer interaction, advanced portable computer hardware technologies, and potential training applications. IMIS will be the culmination of a complex and thorough research and development effort. Specifications developed by the project will be validated through field tests performed by Air Force maintenance technicians. As a result, IMIS will improve the capabilities of maintenance organizations to effectively utilize available manpower and resources to meet combat sortie generation requirements.

In the work being reported, representative base-level maintenance training requirements were identified. Based on these requirements, a series of "operational scenarios" were developed to help conceptualize how IMIS technology might be used to support base-level maintenance training. Based on this work, it appears that IMIS can improve upon present methods used to provide this training.

PREFACE

This report documents the findings of an analysis conducted for the Air Force Human Resources Laboratory, Logistics and Human Factors Division, under contract F33615-85-C-0010, Task Order 0010-02. The task manager was Dr. Donald L. Thomas, AFHRL/LRC.

The following individuals were extremely helpful in collecting the information required for this effort: Capt Kell Cox, Commandant FTD 311; MSGT William Mitchell, Superintendent FTD 311; CMSGT James Wilson, 56TTW/MAT; Capt John Reeder, ASD/B1LAT; and SMSGT Joseph Trimble, ASD/XPQA.

The research was performed by the Dayton office of SEI principal investigators Craig M. Brandt and Johnnie H. Jernigan. They were assisted by Ronald J. Dierker.

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I. INTRODUCTION

In its efforts to improve the maintenance environment, the Air Force Human Resources Laboratory (AFHRL) is investigating potential uses of the Integrated Maintenance Information System (IMIS) for base-level maintenance training. By employing the same sources of data needed for actual maintenance (i.e., technical data, maintenance data, and diagnostics modules), training of the maintenance technician can be improved and enhanced. The technological capabilities possessed by the portable computer can offer a variety of improvements in current training methods through application of computer-assisted instruction (CAI) and computer-managed instruction (CMI).

II. METHODOLOGY

On 26-28 August 1986, representatives of Systems Exploration, Incorporated (SEI) visited MacDill AFB FL to ascertain current methods of maintenance training in use at Field Training Detachment (FTD) 311 and at the 56th Tactical Training Wing (TTW). MacDill AFB was chosen because, as a Tactical Air Command (TAC) base with F-16 squadrons assigned, it is representative of future tactical fighter environments for which IMIS is planned.

During the visit, SEI presented to the assembled faculty of the FTD a briefing on IMIS and its purported benefits. This presentation served to introduce the instructors to the IMIS program so that they could better visualize how IMIS could be adapted to maintenance training. Following the presentation, interviews were conducted with individual instructors in several Air Force specialty codes (AFSCs) to determine the current instructional techniques in use, the training aids employed, and the typical composition of each class in terms of students. Discussions were then directed toward how the portable computer might assist in the training program.

At 56TTW/MAT, a short introduction to IMIS was provided again, followed by a group discussion with members of the staff. Topics included training, techniques employed, and individual training records for the Maintenance Qualification Training (MQT) portion of the Aircraft Maintenance Qualification Program (AMQP). There was also a discussion of the requirements for certification and recurring training.

To guide the identification of base-level training requirements, a series of questions was developed to focus on those aspects of training believed to be suitable for the introduction of IMIS. These questions are listed below:

1. What types of training are now conducted are at base level?

2. Who are the candidates for maintenance training?

3. What training techniques are currently used in the classroom and for on-the-job training (OJT)? To what extent are CAI, CMI, or artificial intelligence (AI) employed?

4. How are diagnostics taught today?

5. What individualized training is conducted?

6. Is embedded training being used?

7. What are the administrative requirements for reporting the completion of training? What are the systems for maintaining training records?

8. How will RIVET WORKFORCE change current training requirements?

9. Will there be differences among the reactions of the various Major Commands (MAJCOMs) to IMIS? Are these differences significant?

10. How is remedial and enrichment training conducted today?

11. How much training is self-paced?

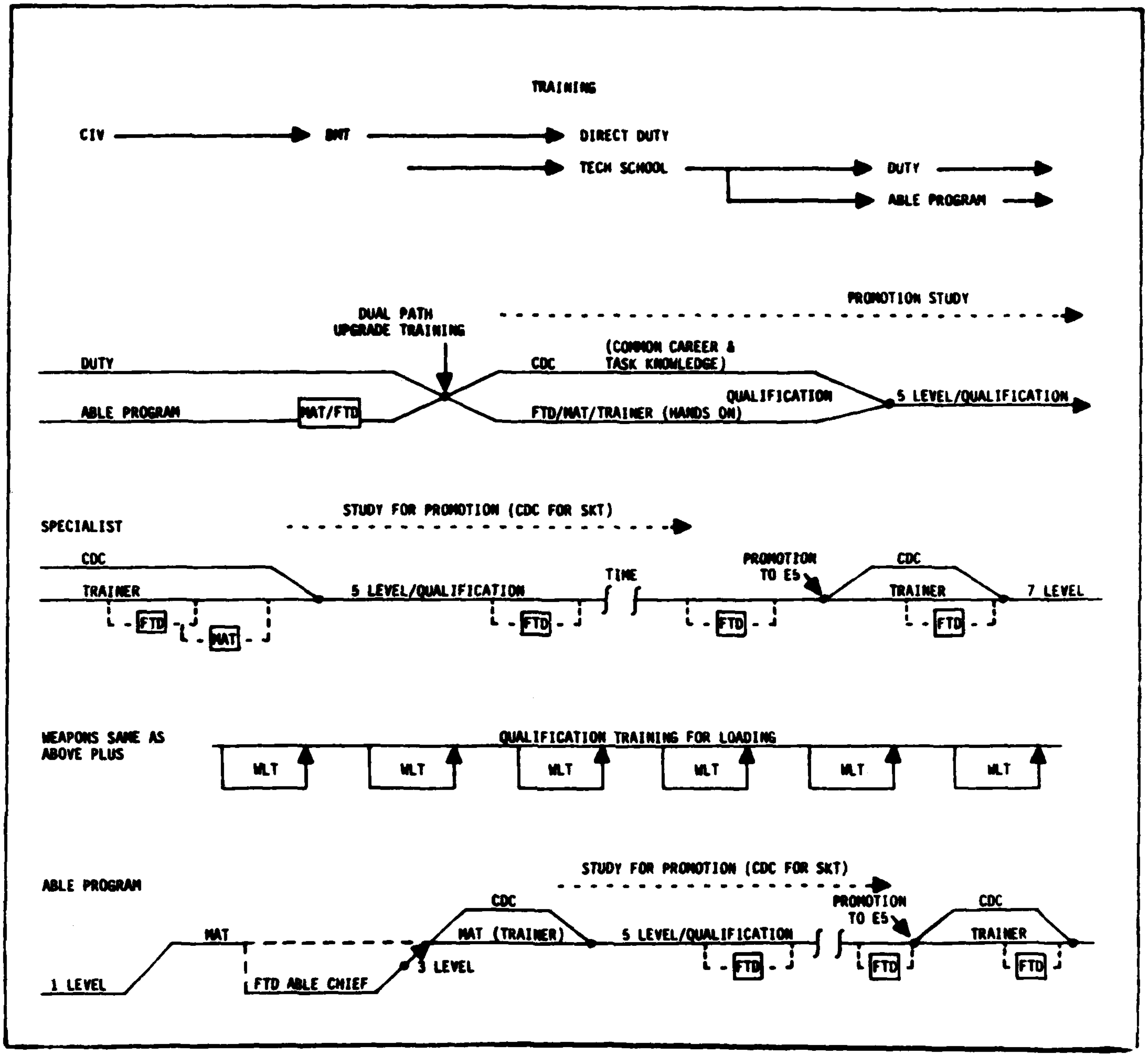
12. What techniques are being used for tutorials, drill and practice, gaming, and simulation?

13. How is cross-utilization training being conducted?

Based on the review of training offered both at the FTD and within the maintenance squadron itself, SEI developed a summary in graphic form of the various maintenance training paths which might be encountered at the base level and the personnel who receive this training. This graphic representation, shown in Figure 1, served as an outline for the various scenarios in this paper.

In addition to on-site visits to base-level training facilities, SEI also visited the Maintenance Training Equipment Program Manager in the B-1B System Program Office (SPO) and the Air Training Command (ATC) liaison at the F-16 SPO. The purpose of these contacts was to determine what changes in maintenance training or training equipment might be forthcoming in both Strategic Air Command (SAC) and TAC. In both cases, there appears to be a trend toward software-driven simulators, often combined with interactive videodisc systems. In addition, TAC is buying videodisc training systems for procedural training in the MAT organization rather than in the FTDs.

Finally, SEI reviewed a number of studies on the use of computers in training, especially Air Force maintenance training. This review highlighted areas where it may be profitable to introduce CAI, capabilities/limitations of CAI, and other issues concerning maintenance training. The reports and articles reviewed are listed in Appendix A.



Other training:

First Aid	Pallet Buildup
Cardiopulmonary Resuscitation (CPR)	Gas Mask
Egress	Cross-Utilization Training (CUT)
Drivers	Cross-Training
Fire Extinguishing	Conversion Training

Figure 1. Possible Paths for USAF Maintenance Training.

III. SCENARIOS

In developing appropriate scenarios for the use of IMIS in a training environment, responses to the questions mentioned earlier assisted us in identifying the most likely situations for employing IMIS. Although it was not the intent of this investigation to provide a complete description of base-level training, a summary of the salient features relevant to the introduction of IMIS is helpful.

For the training diagrammed in Figure 1, the traditional training techniques of lecture, demonstration, and self-study of correspondence courses are used. In general, CAI is limited to specific software-driven training simulators. CMI is used somewhat in the FTDs for scheduling, rosters, and records of completion, but the systems are not ordinarily integrated directly with course materials or examinations. AI applications are virtually non-existent among the training aids currently in use.

Currently, most diagnostics training is conducted using simulators in which a limited number of faults may be introduced by the instructor. The student, using the troubleshooting tree in the job guide, attempts to locate the problem. Although the student learns the basics of diagnostic techniques, he/she is limited to predetermined faults which may or may not correspond with the actual failures or their frequency.

Individualized training is often limited to the Career Development Course (CDC) program. Self-paced instruction is not much in evidence, although self-study videotape lessons are available in some areas. Remedial training often entails reaccomplishing the same lesson, with perhaps closer supervision by the instructor. Beyond the normal coursework, there is little available enrichment training. Most of the training consists of lectures, along with exercises for drill and practice. The use of simulators seems to be spreading, but such training devices are still not available for many career fields.

Administrative requirements relevant to reporting training are extensive, especially for OJT. The basic training record is kept manually, but training accomplishment is recorded in the automated Maintenance Management Information Control System (MMICS) training subsystem.

Cross-utilization training is conducted as a normal part of the FTD or MAT training. Few special courses are developed specifically for this effort. From the view of personnel in the field, RIVET WORKFORCE will simply be more cross-utilization training.

As a result of our analysis of base-level training requirements and the possibilities for using IMIS in a training mode, several hypothetical training scenarios were developed. It was intended that each scenario highlight one or more aspects of current/future training where IMIS technology can be applied. Although each scenario treats only a small segment of maintenance training, the scenarios viewed as a whole indicate the applicability of IMIS for an integrated maintenance training program.

Scenario 1

Like many of the other instructors in the FTD, MSgt Martinez, the communications/navigation instructor, taught before the introduction of IMIS into flightline maintenance and maintenance training. Consequently, he feels confident to judge whether there have been real improvements in training with these IMIS portable computers or whether the addition of high-tech gadgetry only makes it seem so.

One aspect of IMIS that has really helped him as a classroom instructor is the automation of technical order information. IMIS, as the delivery vehicle for technical data provided by the Automated Technical Order System (ATOS), has greatly simplified the use of tech orders (TOs). The ability of IMIS to pull together information that was previously scattered throughout several volumes of manuals and to present the information required for a specific problem in a logical and meaningful fashion has been a boon to the technician. From Martinez's viewpoint as an instructor, this method of presentation has greatly streamlined the teaching process, since the students no longer have to fumble with the tech orders to find what they need. This process has always been especially time-consuming, and for the inexperienced student, particularly frustrating. With this stumbling block removed, the instructor can spend more time on the technical aspects of the lesson, and the students can concentrate on these aspects rather than searching through stacks of TOs.

The special characteristics of CAI available in IMIS have given Martinez an enhanced capability to teach in his particular specialty. The software in the IMIS training modules permits the highlighting of individual circuits in a schematic diagram. Through the technique of signal flow activation, the theory of operation can be more easily grasped by students who view the improved graphic display. Unlike the old paper TOs, in which circuits were necessarily always shown in the deenergized state, IMIS can demonstrate both energized and deenergized states and can show the circuit in a failed state as well. This technique helps to clarify system operation for most students. Also, the students have their own portable computers for working on individual problems. Martinez frequently hooks one machine to a large screen monitor to serve as a teaching aid when he is explaining circuit theory.

Martinez has also found that another difficulty with TOs that was previously encountered throughout the FTD has been substantially eliminated by the combination of ATOS and IMIS: currency. The ease in updating technical information has simplified the task of ensuring that the configuration in the TO is the same as the aircraft that will be maintained by the students. Because changes are made rapidly, Sgt Martinez no longer has to teach from similar but inexact representations of the equipment.

Martinez also notes a change in FTD administration since the addition of IMIS. Because of the complexity of the IMIS-related courseware, various FTDs no longer serve as the lead in developing certain courses. Instead, there is a centralized development group at FTD headquarters. This centralization was necessitated to eliminate the need for skilled programmers at each field detachment. Consequently, recommended changes have to be communicated to the development group for incorporation and distribution to the field. Although this centralized operation ensures that all detachments have appropriate courseware, it has also meant that increased attention must be paid to configuration management of the courseware.

All in all, Martinez is pleased with IMIS. The removal of the paper TO has been a welcome change, and the features offered by IMIS have definitely improved the teaching of several parts of his course.

Scenario 2

Sgt O'Brien has just arrived at the maintenance squadron, her first duty since leaving tech school where she just completed cross-training to the F-100 Engine Mechanic AFSC and was awarded her 3-skill level. Among her first training priorities is completion of her CDC in order to attain the skills required for certification to the 5-skill level. Today, her CDC course is produced on modules for the IMIS portable computer and is currently available on base without the long delays previously experienced when CDCs had to be sent from the Extension Course Institute (ECI).

The new CDCs are self-paced but through imaginative use of computer technology, they are not simply electronically programmed learning lessons. Through the use of intelligent computer-assisted instruction (ICAI), IMIS now conveniently adapts the lesson flow to the individual, based on an internal decision model which selects the most appropriate branch of study according to the student's responses. No longer does each student have to follow exactly the same predetermined path regardless of ability. In addition, the use of highlighting and dynamic graphics provides better instruction than was available in the earlier CDCs.

When O'Brien is ready to do the volume and chapter review exercises, an examination module will be issued by the local training authorities. After completion of an exercise, her score will be automatically computed and downloaded into the appropriate personnel training record. At the same time, directed reviews will be indicated for those questions she missed. Thus, she will receive an immediate response for assistance in those areas where she is weak. A similar technique is used for the course examinations. No longer must these exams be sent to ECI for grading. The record of course completion can be automatically transferred to the automated personnel training record, and an analysis of her test results can be automatically generated.

Besides using the CDC to attain her 5-level, O'Brien will also study the course for her promotion to E-5. However, since she is assigned to an F-16 squadron, she feels that she may be at a disadvantage since examination questions are more likely to deal with the F-15. With IMIS, she can obtain F-15 technical order modules and use them in her preparations. Computerized F-15 technical data are available at her base for use in broadening the skills of the technicians, and she certainly intends to take advantage of this benefit.

Scenario 3

In the classes he teaches at FTD on pneumatic and hydraulic systems, TSgt Lee is blessed with a variety of sophisticated training aids, including a simulated maintenance trainer representing these systems on the advanced tactical fighter (ATF). This simulator is a panel representation of the systems, with flow and equipment actuation graphically demonstrated. This software-driven simulator is also connected to a videodisc player which shows component removal procedures, safety procedures, and equipment and condition identification.

In the course of instruction, the IMIS computer is integrated with the simulator. As a result, the student's use of a portable computer to find the correct technical data for finding the simulated fault is much the same as he/she would be required to do during actual maintenance. Thus, actual maintenance techniques are being reinforced in the classroom.

Although IMIS also has useful self-study programs available using internally generated graphics, Lee finds that the combination of simulator and videodisc provides information in a fashion that facilitates the transfer of learning from the classroom to the flightline. The video presentations assist the inexperienced student in learning equipment locations and correct techniques for working on components.

Scenario 4

SMSgt Thompson, Squadron Training Noncommissioned Officer In Charge (NCOIC), is in the midst of ascertaining the progress of the maintenance training required to allow the Aircraft Maintenance Units (AMUs) to transition to the modified B-model ATF. This transition must take place smoothly, with minimum impact upon the current flying requirements and little or no loss of maintenance capability. This is quite a large task, but thanks to IMIS, it can be done.

By accessing the Core Automated Maintenance System (CAMS), Sgt Thompson can access the training records of those specialists involved in this conversion. Upon gaining access, he can then determine the current status of training, the amount of training required to complete the requirements, the availability of the required training modules, and a projected completion date.

From the automated records, Sgt Thompson notices that SRA Campbell has completed the required evaluations and his status is complete, whereas SRA Warner must still complete the evaluation exercise. Sgt Thompson transfers this information to the production superintendent and flight chief of the appropriate AMU with very little effort. Now, the flight chief, when he checks the status at shift change, can schedule SRA Warner to complete the evaluation.

Sgt Thompson also notices that AMN Roberts failed his evaluation. He passes this information along with a recommendation for remedial training module, RTM014, which covers the missed areas in detail. The personalized remedial training capability of IMIS is a definite improvement over the earlier method. The IMIS remedial modules present information in a different format, using more detailed explanations and requiring more user interaction than the normal training modules. In the past, remedial training provided more punishment than it did training, for it simply consisted of more of the same CDC or study volume that had caused the student problems in the first place. Sgt Thompson has even suggested changing its name to Additional Personnel Enhancement Training (APET), to remove the negative image.

While looking at the current progress, Sgt Thompson plans for the advance training needed for the planned modification to the A-model ATF avionics. He sees that he does not have the required training modules to meet his projected training requirements. He initiates an order for the modules through IMIS to CAMS, which will alert the central training module production center to his needs.

Scenario 5

The introduction of the latest fighter aircraft has brought a significant change in the conduct of Air Force maintenance training. With the high level of built-in test and automatic fault identification within the aircraft itself and with the advent of IMIS, which can accept and process these maintenance requirements via a panel in the aircraft, there has been decreased emphasis on classroom use of equipment simulators. Instead, embedded training, the use of actual on-board equipment rather than mockups or simulator panels, has meant that training responsibility has returned to the line supervisor, who is able to use the aircraft as a training device and IMIS as the training delivery method.

MSgt Washington, a flight chief, has determined from reviewing the CAMS output that SSgt Michaels still lacks qualification in certain skills in diagnostics of the Integrated Electronic Warfare System (INEWS). Since the squadron has a plane not scheduled to fly today and since there are a few hours available between work assignments, Michaels proposes to work on his qualification by using the IMIS in conjunction with the aircraft.

To do this, he selects the appropriate diagnostics module from the training library and hooks up his IMIS portable computer to the interface panel on the aircraft. The software will then induce a fault into the on-board equipment, and Michaels will receive this fault emulation from the aircraft in the same manner as a real fault. The emulation also responds to an external stimulus as if it were a true fault. Using IMIS as a diagnostic aid, Michaels will attempt to locate the fault by employing external test equipment and performing the necessary checks or inputs. Based on its computation of the correct procedural path, IMIS will compare its recommendation with the tests actually selected by Michaels. If he chooses to deviate from the recommended diagnostic sequence, he may eventually reach a non-recoverable position, at which point the IMIS training module will provide explanations of why the incorrect choices were wrong. Even if he is successful in using the non-recommended sequence, the IMIS training module will debrief his sequence against the recommended sequence and show the cost of the deviation. IMIS will also grade the completion of the task by calculating the elapsed time in finding the fault, counting the number of steps taken in the diagnostic sequence, and assessing the impact upon the base logistics cycle.

The training received by Michaels is far more realistic than earlier techniques using mockups and simulator panels. In every step of the diagnostic procedure, Michaels is confronted by exactly the same configuration and test points that he would use in performing actual maintenance. These offer much greater fidelity to a genuine task than would all but the most sophisticated and costly simulators. This capability means that Michaels no longer has to leave his work place to attend classes at the FTD; from the point of view of the squadron commander, this means that no longer must planes be assigned to the FTD for training purposes only, since any aircraft on the ramp can be used.

Scenario 6

SSgt Harris, a crew chief (AFSC 43171), has just launched his aircraft and has a few minutes to think about his future. In line with Air Force efforts to have a "generalist" support force to maintain aircraft at dispersed operating locations where few maintenance facilities are available, Harris is in cross-utilization training for the Integrated Communication Navigation Identification Avionics (ICNIA) field, AFSC 32679A. While he can visualize himself heroically repairing aircraft that have landed on the autobahn, his thoughts drift back to reality, and he decides to spend some time working on his new specialty. He has already received training in basic electronics and the theory of operation of the ICNIA system, but he lacks practical experience in troubleshooting. Harris decides to check out a training module on the ICNIA system which will enable him to develop his skills.

IMIS has four possible options for training in diagnostics, using only the computer as a training aid without any other equipment. It is an ideal way for him to study on his own. The first option allows him to insert a list of faults. Alternatively, he can ask the machine to demonstrate the most frequent fault, the least frequent fault, or a random choice from all possible faults. Since he is very inexperienced in the ICNIA field, Harris elects to have IMIS demonstrate the most common faults.

The instructional package is designed such that the IMIS software can establish a set of initial conditions such as the plausible set of failed components, the set of tests applicable, and the fault codes which would implicate the fault. Those initial conditions are not visible to the student.

After Harris selects either fault codes or symptoms, IMIS will offer a choice of possible tests, ranked in order of preference. He will then review the test procedures for the indicated test and show that the test has been conducted. IMIS will then indicate whether the test has passed or failed. If the test passes and no problem indications are found, the process is reiterated with subsequent tests until an ambiguity group is reached, signifying location of the problem. At this point, the machine indicates the procedures for removal and replacement of the questionable components. Harris chooses to replace the second of these components in the ambiguity group. If this is the faulty component, IMIS will indicate success. Harris must then indicate the necessary functional checks which, if good, will prove that the system has been repaired. If the functional checks are bad, then Harris must return to the diagnostics routine.

This training procedure is developed to lead the specialist through the optimal diagnostic path based on historical maintenance data extracted from CAMS. If Harris had wanted to, he could have chosen a test other than that recommended by the diagnostics program. It would be possible in this instance to "beat the machine" by discovering the failed component earlier than the recommended test procedure would have done. The IMIS will show at the end of each troubleshooting routine how many steps Harris took and how many would have been taken following the recommended test sequence. Since the recommended sequence is an optimal path, it is expected that students attempting to beat the machine will, in the long run, prove that this optimal solution is in fact superior.

Scenario 7

In order to complete a job of hydraulics repair, an engine run is needed for the operational check. MSgt Greene, the flightline maintenance supervisor, is aware of this requirement and must assign a qualified technician to conduct this run. One problem of being a supervisor, Greene notes, is to have to worry about special certification requirements which show currency of training in such areas as egress, quick turns, and hot pit refueling. Greene is aware that engine run is included among these special requirements, so he has to figure out which of his crew chief and engine personnel working this shift have the requisite qualifications.

Using his IMIS portable computer, Greene accesses the training subsystem of CAMS, which contains the qualification records of all maintenance personnel, and easily finds which of his troops can conduct the engine run. He observes that SRA Matthews has only 2 more weeks before his certification period runs out, so he details Matthews to the job. After Matthews completes the engine run and downloads the automatically recorded Maintenance Data Collection (MDC) data from his IMIS into the system, CAMS automatically registers his successful completion of the actual task as fulfilling the certification requirement. Thus, the clock starts over for Matthews' certification period for the engine run qualification.

For Greene, the ability of IMIS to access CAMS for training requirements has been an impressive improvement over old-fashioned manual processing of the AF Form 623 OJT record. Ease of entering training completion into CAMS has resulted in up-to-date records; and the real-time access to information such as the special certification requirements makes it much easier to schedule personnel as the need arises, instead of having to wait 2 or 3 days for a batch-processed report to come out. Via IMIS, Greene can access the CAMS training requirements and use them to schedule the appropriate training.

Today, IMIS can also easily be used for the training itself, simply by requiring the technician to complete the appropriate training module and take the required test, the results of which can automatically be downloaded into CAMS.

Scenario 8

As part of the RIVET WORKFORCE effort to transition personnel from specialists to generalists, TSgt Randolph is being converted from a communications/navigation specialist to a general avionics technician. As an experienced specialist, Randolph of course is familiar with the electronics principles and troubleshooting techniques demanded of his specialty. As part of the conversion, however, he must extend his knowledge across a broader range of equipment, and he must do this, for the most part, on his own.

The ability of IMIS to portray system operation and theory and to execute diagnostics routines makes the portable computer an excellent resource for a skilled technician such as Randolph, since he needs little guidance as he goes through the routines and can benefit from self-study. The real value of IMIS to Randolph is in OJT. To someone in Randolph's position, what this term really means is that he has to work on unfamiliar types of equipment, not maintained by his original AFSC, with virtually no supervision. Because of the way technical order data are portrayed in IMIS, he can ask for extremely detailed procedures (which he might need occasionally) or he can use less detailed explanations (which he would likely need more frequently because of his previous general experience). The diagnostics routines that IMIS offers compensate for his lack of experience with the specific equipment and makes troubleshooting less random and chaotic than it might otherwise be. In fact, *in OJT on an unfamiliar system, IMIS has become his 7-level mentor.*

IV. AREAS FOR CONSIDERATION

1. Certainly, IMIS offers great promise in the field of training; however, there remain to be considered some elements that will affect the cost and usefulness of such a system. For example, at the present time, curriculum development for formal FTD courses is accomplished at a lead FTD, which has the responsibility for producing the necessary course materials used for similar training throughout the Air Force. Thus, although the same course may be disseminated from FTD headquarters at Sheppard AFB, course development is still decentralized. Given the nature of the materials currently used, it is well within the ability of the instructors, regardless of their AFSC, to produce the desired course.

On the other hand, any special training modules prepared for use in conjunction with the IMIS portable computer will require the specialized skills of a programmer familiar with the languages and operating systems used in IMIS. The development of IMIS courseware, then, will not only require subject-matter experts as are currently employed but also necessitate a cadre of computer scientists familiar with the IMIS systems and the techniques for creating training materials on the computer. Even if an authoring system is procured which permits some local production of lesson materials by instructors with minimal computer skills, the bulk of the programming appears to be beyond the scope of most individuals who would be assigned as instructors.

Consequently, a more centralized approach to courseware development is envisioned. At some central location, perhaps FTD headquarters, there would be a core of computer specialists along with a group of technical experts with responsibility for producing the desired training modules for IMIS. As the courses are developed, the software would be delivered to the appropriate training location for implementation, essentially relieving each training site from involvement in developing the courses that will be taught.

If the promise of IMIS's utility in providing accurate, timely learning modules is to be fulfilled, there will have to be a significant effort devoted to configuration management of the training materials. Whereas the updating of a technical data base should ensure that valid information is available for training at all times, there must be a separate effort to update the training materials to reflect new information in those cases where the change will directly affect tests, diagnostics modules, or other specific training applications. Modifications to aircraft will also put great pressures on the management of the courseware. Although changes will not be virtually proscribed, as is the case with some of today's training devices, they will also not be as easy to introduce as in today's system, which is heavily dependent on instructors who can adjust their courses with reasonable facility.

The problems associated with centralization also point to some of the costs associated with IMIS training. At this time, with no firm scheme as to the nature of the IMIS training that will be utilized, it is impossible to compare current and future training costs. Nonetheless, it is certain that courseware development across the entire range of aircraft maintenance will be a costly process. Typically, CAI development costs are quite high in comparison to standard techniques, even though training delivery costs are relatively low. The likelihood of incurring substantial costs in the use of IMIS for training must be considered in the overall IMIS development plans.

2. Centralization of the courseware development, of course, implies some organizational changes in the Air Force training structure, and some proposed IMIS utilization methods may have even more drastic organizational implications. For example, if embedded training is used in conjunction with IMIS, it is possible that the entire function of the FTD might be eliminated in favor of organic training within the maintenance squadron. Such a proposal would mean an extreme reallocation of functions to the operating forces, a consideration which might decide the ultimate acceptance of IMIS in the training community.

Today, the FTD instructors and those in the MAT organizations design their courses independently. In the future IMIS environment, separate development of IMIS courseware will be unwieldy and impractical. Thus, IMIS will require more consolidated control of all base-level training, even if today's organizational entities remain. Both FTD and MAT will have to sacrifice some of their independence in favor of centralized courseware production.

3. One significant advantage of IMIS in the training mode is the real-time access to data systems such as ATOS and CAMS. For the maximum benefits to be received, IMIS must be able to integrate these "live" data with other information contained in the training modules. This appears to be the most significant technological challenge in creating IMIS courseware, since the normal CAI applications use prepared lessons, with all data self-contained within the training module. Creative programming will be necessary to permit iterative interchanges between the data bases and the training module.

4. IMIS can be an ideal means for self-study; however, there may be some drawbacks to the full-scale introduction of IMIS into maintenance training. Although self-study and self-paced study are not necessarily synonymous, how IMIS self-study is integrated into an overall training program must be investigated. If IMIS results only in a programmed learning approach or if it simply substitutes a cathode ray tube (CRT) for the written page, its utility as a training device would be minimal. IMIS must also prove itself in the area of criterion-referenced instruction; that is, in performance-oriented training which will enable the student to perform the required job tasks rather than simply demonstrate knowledge by answering questions on tests. Criterion-based self-instruction has been used successfully in a number of cases.

5. Because IMIS offers the opportunity of introducing dramatic changes in the maintenance training field of the future, early planning for such an eventuality is essential. In its fullest conceivable use, IMIS can have a significant impact on training personnel, training course development, and training devices to be used for maintenance training. IMIS-based training must be considered in the earliest Instructional Systems Development (ISD) procedures and in the development of training aids.

V. SUMMARY

In general, our investigation suggests that IMIS offers advantages in Air Force maintenance training, both in terms of adding IMIS to the existing training structure and in the future, taking advantage of IMIS technology to create a revised training environment. Potential areas of major benefit are described below.

1. Although not designed specifically for training purposes, IMIS's capability to use automated technical order information promises to be of major significance in maintenance training and in the field. Simplified access to technical information will reduce students' efforts to locate information which today may be scattered throughout a multi-volume TO. For the inexperienced student, this capability will offer increased exposure to pertinent tech data and permit their attention to be focused on the technical problem rather than the search for information. For the experienced student, it will still represent a significant time savings in accessing the necessary information. In the formal classroom, this will reduce the amount of

instructor time spent in teaching the use of the manual. For self-study, the automated TO not only will be more convenient but should also eliminate much of the frustration associated with locating desired information. This would be especially important in self-paced instruction, where there is no instructor to provide assistance.

2. Widespread use of the IMIS portable computer for maintenance will provide a common device for delivering CAI. One significant advantage of CAI is the capability to present interactive lessons that are substantially different from those in written texts. This unique characteristic, when applied in tutorials, simulations, and games, can furnish the most responsive and individualized instruction of any medium. Experienced instructors are unanimous in their opinion that, unless IMIS contains these features, it will be nothing more than an electronic page-turner -- which would be extremely costly compared to traditional texts.

To the extent that IMIS can employ AI in its training modules, intelligent CAI can further enhance computer-delivered training by adapting the lesson flow to individual training needs. Self-paced study could then be tailored not only to the neophyte, who must go step-by-step through a training course, but also to the experienced technician interested in cross-utilization training or learning about modifications or new types of equipment.

Because CAI is capable of dynamic communications and presentations, IMIS could improve maintenance training through such techniques as highlighting circuits on schematics or graphically demonstrating fluid flow. These presentations can be accommodated by a computer much more effectively than by color-coding of static representations, for example. Through imaginative simulations and games and creative graphics, a higher level of motivation among students can possibly be attained.

3. The possibilities offered by IMIS in CMI are also noteworthy. Currently available CMI software permits ease in scheduling student assignments, administering tests, scoring tests, and recording the results. To the extent that IMIS is used for self-study, these capabilities could relieve much of the administrative burden currently placed on local training personnel and those involved in CDC-grading at ECI. This improvement would be of particular benefit to OJT managers (AFSC 751X2).

Through an interface beteen IMIS and the CAMS training subsystem, the record-keeping of maintenance training could be vastly simplified and kept current. With the capability to make real-time updates to the system and extract the most current information, line supervision will no longer be dependent on slow batch processing.

4. Current diagnostics training usually involves inducing a fault in a simulator designed to represent a small number of malfunctions, and then, by using the troubleshooting tree in the job guide, going through the necessary steps until the fault is isolated. Such a procedure is a logical treatment, but it ignores actual component failure rates, and possibly more efficient

sequences than those in the technical order. An experienced technician would realize this, but the ordinary training program cannot capture this experience satisfactorily.

On the other hand, IMIS's diagnostics module is designed to incorporate these historical data. As a result, the troubleshooting sequences embedded within IMIS and taught to the trainee are more apt to approximate those employed by experienced maintenance personnel.

It is expected that IMIS could be used in conjunction with maintenance training aids; however, IMIS itself can be used to teach the concepts of diagnostics, without reference to costly simulators. Used alone, IMIS could offer options for the selection of failed components and could then lead the student through the appropriate test sequences to discover the fault. Consequently, the student could become familiar with the full range of test procedures, with no other equipment than the IMIS portable computer. This technique, then, could be used to teach the behavioral component of diagnostics in a better way than using the simulator and tech order, and without the additional requirement for expensive equipment.

5. Since IMIS is being developed as the sole maintenance aid for flightline maintenance, it could clearly serve in the same manner for training. Given the trend toward larger and more sophisticated software-driven training mockups, both for the FTDs as well as the user commands, the use of IMIS as an adjunct to these sizable investments should be considered. With the ability to access ATOS data, IMIS will replace the need for paper T.O.s. IMIS offers an additional advantage in that training modules can be used as direct inputs to software-driven devices such as videodisc machines or other simulators.

IMIS could also impact the use of/requirement for training aids. By connecting IMIS to the aircraft through the interface panel, IMIS could generate software-induced faults in the on-board equipment. This capability would afford greater realism in maintenance training, as actual components, test equipment, and test procedures could be employed.

VI. RECOMMENDATIONS

The clear potential of IMIS for maintenance training makes it essential that current planning for IMIS include the training function. To ensure equal consideration of this function, the following recommendations are offered:

1. Future efforts to develop more advanced prototypes of IMIS portable computers should include the requirement for utilizing training modules. The requirements in the IMIS Statement of Work (SOW) currently being prepared should ensure that all techniques needed for training presentation are included in the capabilities of the computer and that evaluations of the computer include its training aspects.

2. A demonstration of IMIS learning modules should be developed. These would focus on the technological ability to access additional data bases of technical information and historical maintenance data and to integrate these

into a training lesson. This demonstration should conclude with a field demonstration to determine how base-level training personnel react to this concept.

3. Work on the IMIS training function must proceed in parallel with the training aspects of CAMS and ATOS, the systems IMIS is intended to integrate, as well as with developments in the training community. A close relationship must be established between IMIS and CAMS since there can be a direct link with the CAMS training subsystem. Unless ATOS data can be readily employed by IMIS, one of the principal benefits of training, the automated tech order, will be lost. By establishing early liaison with Air Training Command (ATC) and the using commands, AFHRL will be in a position to know how IMIS can be integrated into the long-range training plans of the Air Force.

APPENDIX A: BIBLIOGRAPHY

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